

Description of kV and mAs Parameter Variations in Conventional Radiography with Computed Radiography (CR) Modality on the Same Object Producing Readable Images

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Abstract

Background: Radiographic examinations play a crucial role in the diagnostic process and in evaluating medical conditions. The quality of radiographic images is strongly influenced by exposure parameters, particularly tube voltage (kV) and tube current-exposure time (mAs). Appropriate adjustment of these parameters is essential to produce diagnostic images with adequate clarity while minimizing radiation exposure. **Objective:** This study aimed to analyze the variations of kV and mAs parameters in conventional radiography using the Computed Radiography (CR) modality on thorax imaging with the same object thickness in order to obtain diagnostically readable images. **Method:** This study employed a quantitative experimental design conducted at the Radiology Department of RSUD Dr. H. Ishak Umarella from June to August 2025. The independent variables were variations in tube voltage (60, 65, and 70 kV) and mAs (0.025, 0.028, and 0.032), while the dependent variable was radiographic image quality. Image quality was evaluated based on four parameters: density, contrast, sharpness, and detail. The resulting radiographic images were assessed by three radiographer observers using a standardized evaluation checklist. **Results:** The results indicated that variations in kV and mAs significantly affected the quality of thorax radiographic images. The optimal image quality was obtained at 70 kV combined with mAs values of 0.025–0.032, producing images that were considered sufficiently clear in terms of density, contrast, sharpness, and detail. **Conclusion:** Variations in kV and mAs parameters influence thorax radiographic image quality. The use of higher kV combined with relatively lower mAs values is recommended to produce diagnostically readable images while maintaining a lower radiation dose.

Keywords: kV variation, mAs, radiographic image quality, computed radiography

INTRODUCTION

Radiographic examinations play a fundamental role in modern medical diagnostics and in the monitoring of therapeutic interventions [1]. As one of the most widely used imaging modalities, radiography enables visualization of internal anatomical structures, thereby assisting clinicians in identifying pathological conditions and determining appropriate treatment strategies [2]. The diagnostic value of radiographic examinations largely depends on the quality of the resulting images.

High-quality radiographic images are essential for ensuring accurate interpretation and reliable diagnosis [3]. Image quality in radiography is influenced by several technical and

physical factors, including tube voltage (kV), tube current (mA), exposure time (s), the distance between the radiation source and the object, object thickness, and the size of the irradiated field [2,3]. Appropriate adjustment of these exposure parameters is therefore necessary to obtain optimal radiographic images that clearly represent the anatomical structures being examined [4].

In radio-diagnostic procedures, the selection of exposure factors such as kilovoltage (kV) and milliamperere-seconds (mAs) must be carefully considered [5]. Improper or excessive use of these parameters can negatively affect image quality and increase the radiation dose received by the patient [6]. The primary objective of radiographic imaging is to produce diagnostically readable images that provide clear and accurate information while maintaining radiation exposure at the lowest possible level [7].

Tube voltage (kV) represents the potential difference between the anode and cathode of the X-ray tube [8]. This parameter determines the kinetic energy and velocity of electrons that are accelerated toward the target [9]. Consequently, the magnitude of tube voltage directly influences the energy and penetrating power of the produced X-ray beam [10]. An increase in kV results in greater X-ray penetration through the examined object, which can significantly affect the appearance and quality of the radiographic image [11].

Tube current, measured in milliamperes (mA), represents the flow of electrical current between the cathode and anode within the X-ray tube [12]. This current determines the number of electrons that strike the target and subsequently produce X-rays [13]. In practical applications, tube current is combined with exposure time (seconds) to form the parameter known as milliamperere-seconds (mAs), which reflects the total quantity of X-ray photons generated during the exposure process [14]. Variations in mAs primarily influence the density or degree of blackening of the radiographic image [15].

Another important factor influencing radiographic image quality is the thickness of the object being examined [16]. Anatomical structures with greater thickness require higher levels of X-ray penetration to produce a clearly visible image [17]. Consequently, increased values of kV and mAs are often necessary when imaging thicker anatomical regions. However, these adjustments must be performed carefully because increasing exposure parameters also leads to higher radiation doses received by the patient [18].

Radiographic image quality can be defined as the ability of an image to accurately represent the anatomical structures being examined while maintaining sufficient clarity for diagnostic interpretation. Several key parameters are commonly used to evaluate radiographic image quality, including image density, contrast, sharpness, and the level of visible detail [19]. These parameters are strongly influenced by exposure factors such as kV, mA, and exposure time, which determine the intensity and characteristics of the X-ray beam used during imaging.

Furthermore, increasing tube voltage (kV) can lead to several consequences that must be carefully considered. Higher kV values generally increase the penetration ability of X-rays; however, they may also reduce image contrast due to a broader range of X-ray energies and an increase in scattered radiation reaching the image receptor [20]. Additionally, changes in exposure parameters may affect the interaction of radiation within the imaging medium, potentially influencing the final radiographic outcome. Therefore, accurate calibration and proper control of exposure parameters are essential to ensure reliable measurements of kV, mA, and exposure time in radiographic practice [21].

Considering the importance of optimizing exposure parameters to obtain high-quality radiographic images while minimizing radiation dose, it is necessary to evaluate the effects of variations in kV and mAs in thorax radiography. This study was conducted to analyze the influence of different combinations of kV and mAs parameters in conventional radiography using the Computed Radiography (CR) modality on thorax imaging with the same object thickness, in order to determine exposure settings capable of producing diagnostically readable images.

METHOD

Study Design

This study employed a quantitative approach using an experimental design. Experimental research is defined as a research method used to determine the effect of a particular treatment or intervention on other variables under controlled conditions. In this study, the experimental approach was applied to analyze the effect of variations in tube voltage (kV) and milliampere-seconds (mAs) on the quality of thorax radiographic images.

The research was conducted at the Radiology Department of RSUD Dr. H. Ishak Umarella from June to August 2025 using conventional radiography equipment with a Computed Radiography (CR) modality. The independent variables in this study were variations in tube voltage (60 kV, 65 kV, and 70 kV) and mAs (0.025, 0.028, and 0.032). The dependent variable was the quality of the radiographic image produced.

Image Acquisition Procedure

Thorax radiographic images were obtained using the same object to maintain consistent object thickness across all exposures. Each image was produced using different combinations of kV and mAs exposure parameters. A total of nine exposure combinations were generated from the three variations of kV and three variations of mAs. The exposure process involved adjusting tube voltage, tube current, and exposure time according to the predetermined combinations. All resulting radiographic images were stored in JPEG format for further evaluation and analysis.

Image Quality Assessment

The quality of the radiographic images was evaluated based on four main parameters: density, contrast, sharpness, and detail. These parameters represent essential indicators of

radiographic image quality and are commonly used in radiographic evaluation. The assessment of image quality was conducted by three radiographer observers working in the Radiology Department of RSUD Dr. H. Ishak Umarella. Each observer independently evaluated the radiographic images using a structured observation checklist and a predefined rating scale. The scoring criteria used in the evaluation were as follows:

- Score 1: Not clear
- Score 2: Less clear
- Score 3: Fairly clear

Each image was assessed based on the four evaluation parameters, and the scores provided by the three observers were recorded for analysis.

Data Analysis

The collected data were analyzed using descriptive statistical methods. The scores given by the three observers for each image were summed and then averaged to obtain the final evaluation score for each combination of kV and mAs.

The mean value was calculated using the following formula:

$$\text{Mean (X)} = \Sigma X / N$$

where:

ΣX = total score obtained from all observers

N = number of observers (3 radiographers)

The results were subsequently presented in the form of frequency distribution tables to illustrate the relationship between variations in kV and mAs and the resulting radiographic image quality. This analysis was conducted to determine which combination of exposure parameters produced the most diagnostically readable thorax radiographic images.

RESULTS AND DISCUSSION

The study on radiographic image quality was conducted to evaluate the effect of exposure factors on the visual characteristics of thorax radiographic images. The data obtained consisted of thorax radiographs that were visually assessed using an observation checklist by three radiographers working at the Radiology Department of RSUD Dr. H. Ishak Umarella. The image evaluation was carried out from August 6 to August 9, 2025. The exposure process was performed by adjusting the tube voltage, tube current, and exposure time using conventional radiography equipment with a Computed Radiography (CR) modality. The assessment of radiographic image quality was based on several visualization parameters, including density, contrast, sharpness, and detail. All thorax radiographic images produced during the study were subsequently stored in JPEG file format for documentation and further analysis.

The characteristics of respondents based on their length of employment in the radiology field. The respondents involved in this study consisted of three radiographers with different levels of professional experience. One respondent (YI) had 20 years of work

experience, while the other two respondents, Sr and Ft, had 5 years and 4 years of experience, respectively (Table 1).

Table 1. Respondents' Length of Employment

Respondent	Age	Length of Employment	Occupation
Yl	45 Years	20 Years	Radiographer
Sr	38 Years	5 Years	Radiographer
Ft	25 Years	4 Years	Radiographer

The variation in work experience among the respondents indicates a diversity of professional exposure in radiographic practice. Radiographers with longer working experience generally possess deeper practical knowledge and more refined technical skills in evaluating radiographic images. Extensive professional experience may contribute to greater accuracy in assessing important image quality parameters such as density, contrast, sharpness, and detail.

Meanwhile, respondents with shorter work experience may provide complementary perspectives in image evaluation, particularly in terms of applying current radiographic practices and recent technical knowledge. The combination of respondents with varying levels of experience can therefore enhance the reliability of the assessment results, as it allows image quality evaluation to be viewed from multiple professional perspectives.

In the context of this study, the inclusion of radiographers with different lengths of employment is expected to provide a more balanced and comprehensive evaluation of the radiographic images produced under various kV and mAs exposure parameters. Consequently, the assessment results may reflect both extensive practical experience and relatively recent professional practice in radiographic image interpretation.

The image quality assessment was conducted using an observation checklist completed by three radiographers. The evaluation employed a scoring system with three categories. A score of 3 ("fairly clear") was assigned when the radiographic image demonstrated sufficient clarity in terms of density, contrast, sharpness, and detail for diagnostic analysis. A score of 2 ("less clear") was given when these image quality parameters were present but not sufficiently clear for optimal analysis. A score of 1 ("not clear") was assigned when the radiographic density, contrast, sharpness, and detail were inadequate to allow proper evaluation of the image.

The frequency distribution method was used to evaluate the effect of variations in kV and mAs on thorax radiographic image quality. In this analysis, the researcher combined the assessment results for density, contrast, sharpness, and detail from each respondent. The scores given by the three respondents for each combination of kV and mAs were then summed and analyzed (Table 2).

Table 2. Assessments of radiographic images produced at 60 kV

kV	mAs	R1				R2				R3				Total	Mean
		DS	KO	KT	DE	DS	KO	KT	DE	DS	KO	KT	DE		
60	0,025	3	2	1	2	3	3	2	2	3	3	3	1	28	9,33
	0,028	3	2	1	1	2	2	2	1	3	3	2	1	23	7,66
	0,032	3	2	2	1	2	2	3	2	3	3	3	1	27	9
65	0,025	3	3	2	2	3	3	1	2	3	3	2	1	28	9,33
	0,028	3	2	2	1	2	2	2	2	3	3	3	2	27	9
	0,032	3	2	3	1	3	2	2	2	2	2	2	2	26	8,66
70	0,025	3	3	3	3	2	2	3	3	2	3	3	3	33	11
	0,028	2	3	3	3	2	3	3	3	3	2	3	2	32	10,66
	0,032	2	3	3	2	2	3	3	3	3	3	3	3	33	11

The results show that the radiographic image obtained using an exposure setting of 60 kV and 0.025 mAs achieved a total score of 28, with a mean value of 9.33, which was categorized as less clear. The image produced with an exposure setting of 60 kV and 0.028 mAs obtained a total score of 23, with a mean value of 7.66, also classified as less clear. Meanwhile, the radiographic image generated using 60 kV and 0.032 mAs recorded a total score of 27, with a mean value of 9, which likewise fell into the less clear category.

The evaluation results of the radiographic images were compiled based on the scores provided by each respondent. The radiographic image obtained using an exposure setting of 65 kV and 0.025 mAs achieved a total score of 28, with a mean value of 9.33, which was categorized as less clear. The image produced with an exposure setting of 65 kV and 0.028 mAs obtained a total score of 27, with a mean value of 9, also classified as less clear. Meanwhile, the radiographic image generated using 65 kV and 0.032 mAs recorded a total score of 26, with a mean value of 8.66, which likewise fell into the less clear category.

The assessment results of the radiographic images were compiled based on the scores provided by each respondent. The radiographic image obtained using an exposure setting of 70 kV and 0.025 mAs achieved a total score of 33, with a mean value of 11, which was categorized as fairly clear. The image produced with an exposure setting of 70 kV and 0.028 mAs obtained a total score of 32, with a mean value of 10.66, also classified as fairly clear. Meanwhile, the radiographic image generated using 70 kV and 0.032 mAs recorded a total score of 33, with a mean value of 11, which likewise fell into the fairly clear category.

Effect of Radiographic Quality at Various kV and mAs Settings

The analysis of radiographic image quality in this study was conducted by evaluating several visual parameters, including density, contrast, sharpness, and image detail. Density was assessed based on the level of blackening observed in the radiographic image, while contrast was evaluated by examining the difference in blackening between two adjacent areas of the object. Sharpness

referred to the clarity of the boundaries of the examined object, and detail was determined by the ability of the radiographic image to display the smallest anatomical structures clearly.

According to [22], optimal radiographic images generally present a wide and evenly distributed grayscale range, in which each gray level contains relatively balanced pixel values. The range of grayscale is influenced by the intensity of X-rays penetrating the examined object. Increasing the exposure factor, particularly tube voltage (kV), tends to produce darker images due to higher radiation intensity, which may subsequently reduce image contrast. Tube voltage is therefore considered the primary factor determining the energy of X-rays used to penetrate the object. Meanwhile, changes in tube current affect the movement of electrons from the cathode to the anode during the X-ray production process, which is influenced by voltage and electrical resistance. Under the exposure conditions applied in this study, the mAs values used were able to produce radiographic images that could be adequately interpreted and met acceptable radiographic quality standards.

This study evaluated nine exposure combinations applied to the same object. The resulting radiographic images were assessed using an observation checklist completed by three radiographers. The collected data were compiled into a master table and analyzed using frequency distribution. The results indicated that variations in kV and mAs influenced the quality of thorax radiographic images.

The findings showed that the radiographic image obtained using an exposure setting of 60 kV and 0.025 mAs achieved a total score of 28, with a mean value of 9.33, which was categorized as less clear. Similarly, the exposure combination of 65 kV and 0.025 mAs also produced a total score of 28 with a mean value of 9.33, indicating that the resulting images were still considered less clear. In contrast, higher exposure settings of 70 kV combined with 0.025 mAs and 0.032 mAs produced a total score of 33 with a mean value of 11, which was categorized as fairly clear. These findings indicate that variations in kV and mAs influence the quality of thorax radiographic images.

Based on these results, it can be concluded that the null hypothesis (H_0) is rejected and the alternative hypothesis (H_a) is accepted, indicating that variations in kV and mAs have a significant influence on thorax radiographic image quality. Furthermore, the respondents' evaluations demonstrated differences in radiographic image quality produced by each combination of exposure parameters.

The assumption underlying this study is that variations in kV and mAs parameters influence thorax radiographic image quality. Increasing the kV value enhances the penetrating power of X-rays; however, it may also reduce image contrast due to increased scattered radiation. Meanwhile, appropriate mAs settings improve image density and contribute to better visualization of anatomical details. Thorax thickness also determines the exposure required; therefore, selecting the appropriate combination of exposure parameters is essential to produce diagnostically readable images. This finding is consistent with the results reported in [23], which state that thicker thorax objects require higher exposure factors. Similarly, [24] reported that certain combinations of kV and mAs can produce better image contrast, and that variations in kV influence the anatomical information displayed in radiographic images.

Based on the results of this study, it can also be assumed that the use of the Computed Radiography (CR) system can optimize image quality even when exposure parameter variations are applied in thorax examinations. For a patient with a body weight of 68 kg, height of 165 cm, thorax thickness of 17 cm, chest circumference of 90 cm, and a body mass index (BMI) of 25 kg/m²

(overweight), exposure settings of 70 kV combined with mAs values of 0.025, 0.028, and 0.032 produced images with sufficiently clear density, contrast, sharpness, and detail. These results may also be influenced by the radiography system used in the Radiology Department of RSUD Dr. H. Ishak Umarella, which has a maximum tube voltage capacity of 150 kV and a maximum mAs capacity of 500.

In general, the kV value determines the penetrating ability of X-rays. The higher the tube voltage used, the greater the penetrating power of the X-ray beam, and vice versa. Meanwhile, mAs (milliamperere-second) represents the total quantity of X-rays produced by the X-ray tube during the exposure process. Increasing mAs increases the number of emitted X-ray photons, whereas decreasing mAs reduces the amount of radiation produced [25]. Therefore, kV and mAs are closely related exposure parameters and must be adjusted proportionally according to examination requirements in order to produce optimal radiographic image quality.

CONCLUSION

Based on the results of this study, it can be concluded that variations in exposure parameters, particularly tube voltage (kV) and milliamperere-seconds (mAs), significantly influence the quality of thorax radiographic images in terms of density, contrast, sharpness, and detail. The findings indicate that the appropriate selection of exposure factors is essential to produce diagnostically readable images while maintaining optimal image quality. Higher kV values increase the penetrating power of X-rays, which is beneficial for imaging thicker anatomical structures, while appropriate mAs settings contribute to improved image density and the visibility of anatomical details. In this study, the optimal exposure parameters for a patient with a body weight of 68 kg, height of 165 cm, thorax thickness of 17 cm, chest circumference of 90 cm, and a body mass index (BMI) of 25 kg/m² (overweight) were identified as 70 kV combined with mAs values of 0.025, 0.028, and 0.032, which produced radiographic images with sufficiently clear density, contrast, sharpness, and detail. Therefore, the selection of appropriate kV and mAs combinations is crucial in thorax radiography to obtain optimal diagnostic images while minimizing unnecessary radiation exposure to the patient.

RECOMMENDATIONS

The exposure parameters identified as optimal in this study are expected to provide practical benefits and be applied in radiology services at the Radiology Department of RSUD dr. H. Ishak Umarella. By implementing these parameters, the radiation dose received by patients can be optimized while minimizing potential adverse effects of radiation. Additionally, the researcher welcomes any feedback, criticism, and suggestions as valuable input to improve future research.

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